

O L E G P I S A R Z H E V S K Y

THE
WORLD
OF
SOVIET
SCIENCE

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**IN THE WORLD OF
SOVIET SCIENCE**

*Notes on the latest research
of Soviet scientists*

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IN THE WORLD OF SOVIET SCIENCE

“Growing Points”

CAN THE SEA be drained by means of a thimble? Can one presume to give in a brief survey even a most general outline of the latest achievements in science in a vast country which is developing a most advanced industry and progressive agriculture? One is obliged to choose from an immense variety of subjects. To facilitate my task, I strain my memory: what has of late excited most of all the imagination of diverse people—the scientists themselves, as well as workers in other spheres of culture uninitiated in the mysterious and fascinating world of the laboratory with its super-sensitive instruments and its discoveries which stab the sky like lightning. This is the most convenient criterion. All Soviet people are united by a community of purpose and tasks. They all regard science as one of the most important means of achieving this purpose. And this purpose is determined by the supreme law of socialist society: everything for man's welfare!

The specific ways of the development of science in the USSR are, of course, not to be sought in prescribed formulas, identical in all the continents, and not in the special qualities of materials, machines or technological processes which are governed everywhere by uniform laws of nature. The specific features of the Soviet system are manifest in the approach to science as a powerful instrument for the conquest of nature, for creating an abundance of material wealth and for the development of culture.

As for science itself, its distinguishing feature in the USSR is not only supreme humaneness, but also

the greatest optimism. It permeates all the searchings of the Soviet scientists. This optimism rests upon the conviction that man is capable of plumbing all objective truths, that there is nothing unknowable in nature, but only some things still unknown. The distinctive feature of Soviet science lies in the harmonious combination of soaring flights in theory with its constant practical purposefulness. In the Soviet Union there is no artificial isolation of science from life, of theory from practice.

The scientific forces in the USSR are most fully employed in the solution of urgent problems connected with the development of national economy; the scientists generalise the advanced experience of the practical workers. This great task cannot be successfully accomplished without the solution of theoretical problems. And the very methods of scientific research must be constantly developed. Theory and method constitute science's arsenal which requires constant renewal and perfection.

At the same time we refuse to be passive recorders of the process of cognition. And this implies primarily the concentration of the forces of the scientific front on the solution of the major, pivotal problems. The proper choice of these problems is the fundamental question in planning science. The accomplishment of this task is ensured by the conditions of socialised production. The planning of science is a scientific problem of colossal nationwide scope. The leading scientific staffs of the country, and, primarily, of the Academy of Sciences of the USSR, the headquarters of scientific thought, cooperate in this work. The most decisive factor for the successful accomplishment of these tremendous tasks is that Soviet science is equipped with so powerful a method of studying nature as Marxist-Leninist dialectics.

The task of planning science was graphically formulated by the President of the Academy of Sciences of the USSR; Academician Alexander Nesmeyanov, when he wrote recently:

“Just as a plant has its definite growing points so does science have its own growing points in every period of time and in concrete conditions; they are determined by the interaction of science and practice, and of the different fields of science. It is our task to anticipate and detect these points, which are barely perceptible at first but hold out the promise of rapid growth tomorrow, to master them and concentrate our forces on them.”

These “growing points” in Soviet science are determined by the requirements of the rapidly developing national economy and techniques, and by the methodological requirements of science itself.

What are these “growing points”?

They originate in the first place where the multi-form requirements of national economy demand the simultaneous cooperation of various branches of science. Among these composite scientific problems is, for example, the problem of rational distribution of productive forces, exploration of the natural resources and their development in the desired direction. Its solution requires the combined efforts of geographers and geologists, economists and soil scientists, hydro-power engineers, botanists and representatives of many other sciences.

The “growing points” in Soviet science are determined by the development of higher techniques for securing the continuous expansion and perfection of socialist production for the maximum satisfaction of the constantly rising requirements of the Soviet people. In addition to the technical sciences, this demands the concentration of the forces of physics which is called

not without reason "the engineering of tomorrow"; of chemistry with its marvellous faculty for creating new materials according to peculiar "chemical blue-prints"; of biology which places in the service of engineering new resources, "organic robots," useful micro-organisms, enzymes, etc.

And it is in the process of this interaction of different branches of knowledge, in the lines of their "contact," so to say, that "growing points" originate most often. Thus, for example, geochemistry, a new science which studies the destiny and participation of different atoms in the development of the structure of the Earth's crust, originated at the juncture of geology and chemistry. Another example is biological chemistry, or biochemistry, one of the most promising of the new sciences which discloses the finest chemical "mechanism" of life. Its achievements stimulate the development of agriculture, physiology and medicine which concerns everyone of us so directly. This applies also to geophysics which is boldly using a splendid set of physical methods for penetrating scores of miles deep into the bowels of the Earth and studying the mysteries of the stratosphere. And there is radio-astronomy, a sphere of astrophysics which is successfully tapping the "whispers of stars," interpreting the radio signals announcing the birth of new worlds in the depths of the Universe.

And, lastly, this applies to all the fields of science and technique the progress of which is stimulated by the most important discoveries of modern science, be it the explosion of an atom or the directed alteration of an organism.

Let us follow up the development of some of these "growing points" — new fields of knowledge or old fields of knowledge in which new ground has been broken.

The Birth of Worlds

THREE QUESTIONS HAVE invariably roused the burning interest of mankind in the course of the ages: how do stars and planets form and develop in the Universe? How did the Earth originate? How did life in general, and man in particular, appear on Earth?

The quest for an answer to these questions brings out the Promethean fire of learning which is inherent in us. The mysteries of nature have always excited man's imagination. Each new discovery raises new questions.

But the development of cosmogony is also of practical value. Indeed, hundreds of small earthquakes take place in the world daily, and violent earthquakes occur quite often. How can we learn to anticipate them if their causes remain a mystery to us? And these causes are connected with the entire history of the Earth's origin and development. We dream of an all-round utilisation of solar energy. Then how can we help seeking the cause and nature of its radiation. The Sun's radiation, we feel, would seem to be constant. But navigators, especially in the Northern latitudes, are well aware of magnetic storms. Any radio specialist will tell you of disastrous interferences in reception which have their source in gigantic splashes in remote ultra-violet parts of the solar spectrum and in radio frequencies. Complete understanding of these phenomena, which are acquiring increasing practical value for man's endeavours, is impossible without knowledge of the laws governing the evolution of the Sun and stars.

Both science and life demand in equal measure of cosmogony a wide treatment of problems, bold generalisations and profound solutions of general problems. And this is how Soviet astronomers understand their mission. Failing this, millions of astronomic observa-

tions recorded on photographic plates throughout the world will pile up uselessly on the shelves, collecting *dust; failing this, there is the danger that the investigations of "the labourers of science," as the astronomic observers are sometimes called, will degenerate into senseless collectorship.*

Soviet scientists have lately made new contributions to astrophysics, the science which deals with the nature of heavenly bodies, and to stellar astronomy, another branch which deals with the structure and dynamics of stellar systems.

Soviet astronomers are not merely collecting observations of the stars and stellar systems. They seek to locate and investigate objects of the stellar worlds at a turning point in their evolution and for this reason especially interesting to science.

Thus, Professor Boris Kukarkin has found that stars of different physical types, as regards origin, can be classed among several main types. As shown by the calculations of Soviet astronomers, stars of different physical types possess different mass, and many of them, the so-called "nonstational" stars, wastefully radiate away their substance into space. The hot giants and super-giants of the stellar world rapidly lose their mass through radiation. This and many other observations suggested the idea that the stars are in the process of evolution and that their mass changes at the different stages of this evolution.

But how can the process of formation and evolution of stars be traced? For the life of stars is measured in billions of years. The key to this problem is furnished by observations of the multiform stellar population of our Galaxy.

The talented Soviet astronomer N. Pariisky made the following remark with reference to this: "Observing the trees or plants of different ages in a forest, we can reconstruct pictures of their life even before the

cycle of development is completed. The same is true of stars. Observing the star-studded sky we see stars in different stages of evolution and we may endeavour to reconstruct mentally the whole history of their life. What one has to guard against is the danger of confusing the different "species" of stars which are often mixed in a volume of space just as different species of trees in a mixed forest."

Soviet science has in recent years greatly advanced towards overcoming this difficulty.

A group of Moscow astronomers—Parenago, Kukarkin and their colleagues—has determined many specific features in the structure of our Galaxy and singled out different "species" of stars apparently of varying origin and ways of evolution.

The Moscow astronomers have established that some types of stars form almost globular systems, their density usually increasing towards the centre. Others have a smaller density. And lastly, there are members of the stellar population which constitute almost flat systems. Examples of these are the very hot white and blue giant stars.

The Soviet astrophysicist, Academician Victor Ambartsumyan, conducting, together with a group of his pupils, observations at the Byurokun Observatory (in the mountains of Armenia) directed by him, discovered entirely new formations, so-called stellar associations. These are groups composed of a comparatively small number of stars. To locate them among a vast mass of other stars was possible only by general physical characteristics. It was in this way that associations of very hot white and blue giant stars were discovered. Scientists maintain that the stars in these associations are young. This is substantiated by calculations which suggest that a very rapid process of dispersal is at work in these associations under the influence of the surrounding stars. As picturesquely

expressed by one of V. Ambartsumyan's collaborators, the young astronomer Markaryan, the stars grouped in associations are like birds flying out of the same nest. Had the component stars of the associations existed for a long time, they would have drifted far apart and mixed with the other members of the Galaxy. This is confirmed by the powerful radiation of the hot giant stars. Their energy is expended so rapidly that they cannot exist in the same state for a long time (long, of course, from the viewpoint of the astronomical scale!).

All these numerous facts have furnished ground for the important deduction that the stars of our Galaxy have originated at different times, and, most interesting, that this process of formation continues today.

This idea has lately been elaborated in the remarkable investigations of Academician Vasili Fesenkov. V. Fesenkov conducted his observations in an astrophysical observatory maintained in the mountains near Alma-Ata, capital of the Kazakh SSR, by the Academy of Sciences of Kazakhstan. This observatory is equipped with an original Soviet-built telescope fitted with a meniscal lens designed by the Soviet scientist Prof. Maksutov. The lens is half a metre in diameter. Its aperture ratio makes it possible to photograph very faint heavenly bodies. With the aid of this instrument, Fesenkov and his staff photographed various galactic nebulae—celestial formations composed of gaseous matter (hydrogen in the main) and fine cosmic dust. These photographs revealed fine heretofore unobtainable and astoundingly strange details of these nebulae. Many of these appear to have a fine fibrous structure. One could observe these fibres disintegrate into separate condensations. Some of them appear to be diffused. They may naturally be presumed to be astral embryos. Others have a distinct

stellar shape and form a number of ribbons or chains of closely grouped stars. Incidentally, chains of stars have also been found in the stellar associations discovered by V. Ambartsumyan.

Academician Fesenkov explains this interesting phenomenon as follows: clots of matter originating within separate "fibres" evolve into stars, while the remaining gaseous matter linking the stellar clots is gradually dispersed in interstellar space. Calculations have shown that neither the "fibres" nor the stellar chains born of them can be stable, that they must disintegrate within 100,000 years. (We may note that this is a very negligible period of time from the cosmological point of view.)

Thus, Soviet science has furnished further proof in support of the idea that the birth of stars continues in our time, and that they are born in groups.

We may presume that every compact group of stars—whether it extends in a chain or in a different system—must have originated from another, prestellar, body. Academician Ambartsumyan proposes to call these supposed heavenly bodies "protostars". In this idea, they must have a faint luminosity beyond the range of visible and photographic rays. Thus far, he thought it impossible to go beyond general assumptions with respect to the nature of protostars. Their size may possibly approximate the magnitude of the so-called globules—small, dark, compact spheroidal nebulae with a diameter equal to tenth-parts of a light year. *

Incidentally, the linear extension of these nebulae differs little from the fibres of diffused (i.e. composed

* The gigantic distances between the bodies of the Universe are measured by the time expended by a beam of light to reach them, and the velocity of the latter is known to equal 300,000 km. a second.

of gas and cosmic dust) matter which may be classed in affinity with the stellar chains. These fibres in their turn form a part of diffused nebulae.

Hence the great interest of the scientific world in the new endeavours of Academician Georgi Shain and his collaborator, Gaze, who developed a new method of photographing faint galactic nebulae. In their observations in the Crimean Observatory (in Simeiz), they used very powerful mirror-lens cameras in combination with filters which passed very limited parts of the spectrum. This enabled them, on the one hand, to eliminate skyshine, and, on the other hand, to obtain a photograph of the nebulae in rays of the brightest hydrogenic lines in the nebulae spectrum. The results were astounding. About 100 gaseous nebulae were known before 1949; thrice this number is known now, which means that a new world of stellar formations has practically been discovered. The works of Academician Shain indicate that the origin of groups of stars is in fact most closely connected with diffused gaseous nebulae. In what way? This is a problem for future investigations.

Soviet astrophysics endeavours to reconstruct a correct picture of the world. It represents a group of physicists who are investigating conditions of matter unknown on Earth. How far it is from the outwardly spectacular but helpless and, in essence, miserable constructions of the idealists who deliberately falsify science with the object of "crushing" the materialism they detest. It means nothing to them to announce that from time to time space develops "folds" having five dimensions, and that stars are born out of "nothing" in these folds. They declare without any scruples that the stars have originated before space, and that they represent a kind of "perpetuum mobile" in which energy is generated from "nothing"! Without any foundations and proofs whatever, they build

“theories” and “hypotheses” about the simultaneous birth of stars and their equal age.

Discovering and investigating the processes of the birth of stars, Soviet scientists obtained fresh and convincing proof in support of the correctness of materialist dialectics which teaches us that no one created the world, that it develops in accordance with the laws governing the movement of matter and requires no supernatural power for this. Of course, the problem of the origin and evolution of stars still awaits its final solution, but the achievements of the Soviet scientists lend ground for the conviction that we may expect them to wrest from Nature more and more of her secrets.

We are able to discern in the successes of Soviet astronomy today the rays of its tomorrow's progress also because the Soviet astronomers are provided with first-class equipment. The finest instruments of original design, the superb optical equipment of the observatories attest to the maturity and high level of the Soviet instrument-making industry. The work of the astronomers in the USSR reveals also the fundamental features of Soviet science which derives its strength from its reliance upon facts, upon the creative cooperation of scientists employed in different fields of knowledge who combine efforts for the solution of important problems. While radiophysicists calculate the vibrations of gas in the Sun's corona which is a source of radio waves, and physiochemists decode atomic reactions in the stars, geologists are studying the structure and origin of the lunar configurations, geophysicists create models of the inner structure of planets, meteorologists help to decode the mechanism of dust storms on the surface of Mars and the poisonous hydrogen-methane tornadoes in the atmosphere of Jupiter, and the biologists assist the astronomers in detecting traces of organic life in the Universe.

Life on Mars

IN LITERATURE ON astronomy one may often come across the claim that the Earth is the only planet with life in the Universe. Is this so?

Soviet scientists are convinced that life, which is the highest stage of the evolution of matter, arises of necessity where conditions are favourable for it. We are convinced so in particular by the remarkable adaptability of living organisms to the most rigorous environment. Grass grows on the shores of the Arctic, in Siberia, its leaves and blossoms enduring through bitter cold in winter (when mercury drops to 50° below zero Centigrade), to continue their cycle of life in the spring. In the Pamirs and other mountains one may come across an open blossom bitten by frost in the night with petals as fragile as glass. It thaws in the morning and continues to live. On the other hand, it is known that the blue-green filaments of the Cyanophycene (blue-green algae) growing near an extinct volcano on Kamchatka lived in a stream where the temperature of the water was 82°C .

Considerable progress has been made in the USSR of late in studying the possibility of life on other planets of the solar system. The greatest interest in this respect has always been attracted by Mars which has many features in common with the Earth.

Many investigators have been inclined to assume that the yellow and orange patches visible on a large section of the Martian surface represent a desert. The periodic changes in the colouring of the other part of the planet caused many debates. These changes in the colour of the dark spots resembled seasonal changes in the colour of the terrestrial vegetation. Puzzling was the fact that the colour of what was presumed to be Martian vegetation was in the main not green, but blue, dark blue and even violet.

What are the possibilities of judging about the vegetation of a far-off planet on the basis of its optical properties only? By comparing them with the optical properties of terrestrial vegetation! This problem was raised in 1945 by G. Tikhov, Corresponding Member of the Academy of Sciences of the USSR. His interesting investigations are conducted in the Academy of Sciences of the Kazakh SSR. In recent years, G. Tikhov organised numerous astrobotanical expeditions to the Pamirs, Siberia and to the deserts of Kazakhstan. The results of these expeditions explained the formerly incomprehensible colour properties of Martian vegetation.

The mysterious properties of Martian vegetation were discovered at the very first attempts to photograph it in infra-red rays. When ordinary green terrestrial plants are photographed with the aid of photographic plates sensitive to infra-red rays, they appear very bright as if powdered with white snow. It would be natural to expect that when photographs in infra-red rays are made of the vegetation-covered regions of Mars they would also develop as white spots. But this did not occur.

In order to explain this riddle, Tikhov and his collaborators compared the capacity of plants growing in cold and warm climes to absorb and disperse infra-red rays. This comparison has shown that the power of reflecting infra-red rays by green oats in the central zone of the European part of the Soviet Union, for example, is three times that of juniper growing in the tundra. The climate on Mars is even more severe than in the Soviet North. Apparently under the influence of this environment the plants had acquired the capacity for the complete absorption of infra-red rays.

But this was not the only riddle. The spectroscope makes it possible to decompose the light reflected by green plants. In a definite section of the red rays in

the spectrum thus obtained a dark band may be observed. It indicates that the rays in this section have been absorbed by the plant. And chlorophyll, the same substance which gives the plant its green colour, is responsible for this absorption. Analysing the light reflected by the regions of the Martian surface where the existence of plants was presumed, the scientists however failed to detect the band of chlorophyll absorption. How was this to be explained? And again, the explanation given by Tikhov was that in the severe Martian climate the plants, in order to secure the necessary warmth, must absorb not only the red but also all the other long-wave rays of the visible spectrum. And if this is so, then the band of absorption will not be a narrow line easily discernible as it is the case on Earth.

A characteristic feature of astrobiology, and of the majority of modern sciences studying the Universe for that matter, is that they all lean to one or another degree on direct experiments. Setting out from the generally known observation that in its prime vegetation on Mars has a blue colour, Tikhov undertook to find blue vegetation on Earth. The Canadian silver fir attracting his attention, he photographed the spectrum of its needles; and, indeed, the chlorophyll band was not visible, whereas it stands out conspicuously in the spectrum of the ordinary pine. It is noteworthy that Canada, the home of the silver fir, has a rigorous climate. The Tien-Shan mountain fir was studied from the same angle. In March, when the temperature was above zero, the chlorophyll band was distinctly visible in its spectrum, disappearing when cold weather set in.

These and many other observations confirmed the assumption that the chlorophyll band is absent in the spectrum of Martian vegetation because the climate on Mars is very severe.

But then why has vegetation on Mars a blue

colouring? Tikhov explains it as follows: if the plant absorbs intensively all the rays with the exception of blue, dark blue and violet (and the latter contain the smallest share of spectrum energy), it is precisely the reflection of those, least absorbed rays, that determine its colour.

Every scientific idea acquires power under the fire of criticism. When advancing a hypothesis, the materialistically-thinking scientist is interested primarily in testing it by experiment. If it comes out hardened from the test, it receives its "pass to life." Tikhov examined one by one all the objections that could be raised to his hypothesis concerning the existence of plant life on Mars: the shortage of water, the great dryness of the Martian atmosphere, the shortage of oxygen in it. Thoroughly investigating all these conditions, he found through the study of numerous specimens of terrestrial vegetation interesting instances of the greatest adaptability of plants to similar environmental conditions.

In the Yakut Autonomous Soviet Socialist Republic, in the neighbourhood of the "pole of cold," the climate is no less rigorous than on Mars, and yet about two hundred species of plants grow there. A distinguishing feature of the climate in the Pamirs is extreme dryness of the air, yet this is no obstacle to the life and development of plants. There is a deficiency of oxygen in the atmosphere of Mars, yet we know a vast number of bog and water plants which are excellently adapted to an atmosphere with a reduced oxygen content. "Life is a very persistent phenomenon," concludes the Soviet astronomer Tikhov. "It can exist also under conditions that greatly differ from the average conditions on Earth."

Another characteristic feature of Soviet science is that while perfecting and enriching the existing

methods of research it is constantly seeking new ways of delving into the inmost secrets of nature. This feature is apparent also in the research of Soviet astrobotanists. Its imprint is evident in the interesting investigations of the outstanding Soviet mathematician and geophysicist, Academician Otto Schmidt, who in cooperation with scientists employed in other fields of knowledge has substantiated new views on the history of our planet.

History of the Earth

IN THEIR WORK the Soviet scientists proceed from the idea that the questions of the origin of the Earth and planets are most closely connected with problems of stellar cosmogony. The clue to the origin of the solar system must be sought in the origin of the Sun itself. These problems have always roused heated debates in science. There was a time when the obscurantists conducted a bitter struggle against Kant's "General History of Nature and Theory of the Heavens," against the hypothesis of the French astronomer Laplace that the Sun and the planets had originated from a revolving and compressing mass of gas — a nebula as we would have called it today. The brilliant guesses of Kant and Laplace, progressive for the level of knowledge in their times, have now become contradictory to the newly discovered phenomena and facts.

In accordance with the earlier hypotheses it was believed, for example, that the Earth's crust with a thickness of several score kilometres rests upon molten magma. But the bulk of the Earth was rent by waves of explosions and earthquakes and when these waves were intercepted (and their paths traced) it appeared that they had travelled through thousand-kilometre-thick strata as through a solid body.

The way followed by the Soviet astronomers in their quest for the key to the problem of the origin of the solar system and the Earth itself, is the way of conscientious analysis of facts. And this way has led to most interesting discoveries which are in harmony with the endeavours of the Soviet astronomers who are investigating the processes taking place in the clouds of interstellar dust and gas.

Here are some of the propositions advanced by the school of Academician O. Y. Schmidt which believes that the planets and their satellites were born of cold hard particles, components of the gas-and-dust cloud which had once enveloped the Sun. Academician Schmidt sees the main factors of evolution of this cloud in the force of gravitation and in the process of conversion of mechanical energy into thermal energy. In his opinion, this conversion was taking place through the collision of particles. At this impact mechanical energy frequently passes into heat, i.e. the dust particles are heated. This heat is emanated into space. If the swarm of gas and dust had not been revolving around the Sun, a decline in the relative velocity of its particles would cause them to drop onto the Sun. But in the revolving cloud the particles assembled in its central plane. In this flattened revolving discus the density of matter had grown and the mutual gravitation of the particles acquired a more important role. This engendered the formation of numerous condensations capable of resisting the destructive action of solar gravitation. Each swarm, which was a local condensation in the dust discus, had undergone an evolution. Collisions were taking place also within the discus, with the result that its density was growing under the action of released heat and it developed into the "embryo" of a future planet. There were inevitable local cataclysms, the collision and breaking up of new formations, but the fragments joined immediately the

remaining bodies, which, growing gradually, evolved in the end into big planets. This picture naturally explains the velocity of the movement of planets in relation to the Sun—in one direction, along circular paths lying in the same plane.

The searching thought of the cosmogonists has always paused before the mystery of the rotation of planets on their axes. It would seem that this rotation should take the very opposite direction. A great achievement to the credit of Academician O. Schmidt is his mathematical analysis of this problem which demonstrated that the conversion of a considerable portion of mechanical energy into thermal energy attending the formation of planets from hard particles leads to the origin of a direct rotation, i.e., a rotation in the same direction in which the planets revolve around the Sun. Therein lies the fundamental distinction of O. Schmidt's theory from the old hypotheses: it investigates the process of conversion of mechanical energy into other forms of energy. And this very process determined the direction of the evolution of the primary cloud.

This is also the first time that the theory of the Earth's origin connects its pregeological stage of development with the geological stage. Heretofore, only some great minds, first and foremost among them the celebrated Soviet geochemist Academician Vernadsky, ventured the guess that the Earth and other planets were originally cold. This deduction evolves naturally from O. Schmidt's theory. How does this point of view fit in with the violent volcanic eruptions which indicate that there are regions with high temperatures within the Earth? We have no exhaustive answer to this question thus far. The development of these regions may perhaps be due to later heat processes within the Earth caused by radioactive breakdown.

In accordance with the new viewpoints, the rise in the internal temperature of the Earth was attended by the emanation of gases and water vapours from the rocky substances of the Earth. Bursting to the surface the water vapours had condensed giving rise to seas and oceans, and the gases formed the atmosphere which has changed as a result of the vital functions of organisms. The process of origin of this creative life has been investigated by the Soviet biochemist, Academician Oparin. His theory of the origin of life deserves special attention.

As already mentioned above, the propositions advanced by Academician Schmidt and his school shed a new light upon many problems of geology and geochemistry which seemed to have been solved a long time ago. But very recently, indeed, a large section of geologists, geophysicists and geochemists were guided in their studies of the Earth's crust by the assumptions that within the Earth there was a solid nucleus of nickeliferous iron. This iron was believed to have streamed down when the Earth was in the fiery-liquid state. This hypothesis encountered doubts here and there, but theoretical calculations have now confirmed the most probable assumption that the solid nucleus of the Earth is composed not of iron, but in the main of a rocky substance condensed into a very dense state under monstrous pressure. It has been calculated that at a depth of 250 km. this pressure amounts to 100,000 atmospheres, rising to 1,400,000 on the boundary of the nucleus and exceeding 3 million atmospheres in the centre.

The physics and chemistry treating of high pressures, and, in particular, the endeavours accomplished in this field by the Soviet school of Academician Zelinsky, provide adequate material for a more or less definite judgement of the state of a substance under the action of super-high pressures and high temperatures. It

is believed that the substance within the Earth is not liquid but plastic, capable of shifting slowly under the action of forces operating for a length of time. This explains the fact that under the influence of centrifugal force the Earth has acquired a flattened shape. At the same time, as already mentioned above, earthquake waves travel through it as through a solid body which possesses a resilience greater than that of steel.

The plasticity of the Earth's bowels accounts for the slow dislocation of matter under the force of gravitation, the heavier regions moving downwards and the lighter towards the surface. These slow dislocations which take place in millions and billions of years could create only small concentrations of heavier matter at the Earth's centre. It is assumed that the process of stratification in the depths of the Earth has only begun, its effects on the surface of the Earth being manifested in the rising or sinking of large regions of the Earth's crust and in the form of earthquakes.

The new concepts of the origin of the Earth's crust have substantially changed the views of the geologists. According to the new theory of the Earth's origin, the external layer of our planet originated as a result of the heat processes in the bowels of the Earth, which pushed the lighter molten rock to the surface. These ideas will unquestionably lie at the basis of a new theory of mountain-building which will disclose its connection with the displacements of matter in the depths of the Earth.

The new geophysical picture of the Earth's history is naturally closely connected with geophysical methods of investigating the Earth's inner structure and its evolution. Methods of prospecting of minerals based on the study of specific physical phenomena connected with the structure of the Earth's crust are now widely employed in the USSR. They are called geophysical

methods of prospecting. A great many geological and engineering problems have been solved in the USSR with the aid of these methods. Important geological problems are being solved also through the investigation of the distribution of magnetic forces on the surface of the Earth. Thus for example, in the USSR, in the area of the Kursk magnetic anomalies caused by the existence of vast deposits of quartzite with a large content of magnetite in the Earth's bowels, the local magnetic intensity is more than four times that of its normal magnitude. Magnetic prospecting has been of value not only for studying iron ore deposits. In places where iron ore deposits had formed together with gold, the method of magnetic prospecting has made it possible to study auriferous deposits. Magnetic prospecting has found application in the study of the oil deposits of South Azerbaijan, where strata containing magnetite contribute towards the formation of structures favourable for the accumulation of oil.

Of great interest is the method of studying the structure of the Earth's crust by analysing the nature of the spreading of elastic vibrations in the Earth. These vibrations are usually caused by explosions. As they spread through the Earth and encounter strata of various density and elasticity in their way, these vibrations are refracted and reflected. Accurate seismographs record these "seismic rays" and in various ways draw conclusions about the nature of the investigated deposits. The founder of the seismic method of prospecting, Professor Gamburtsev, emphasised the significance of these methods of prospecting geophysics for the construction of railways, canals, hydro-electric developments, tall buildings, etc.

The young science of geochemistry, one of the divisions of geology, is designated to play an important part in the solution of the new problems before it. Following the classical works of the founders of

this science, Vernadsky and Fersman, the important technical investigations which gained widest renown deal with the distribution of chemical elements in the soils of the East European plain. These investigations were conducted for many years under the guidance of the eminent Soviet geochemist Professor Alexander Vinogradov, Corresponding Member of the Academy of Sciences of the USSR. Together with his collaborators, Professor Alexander Vinogradov investigated the laws governing the behaviour of chemical elements in the process of their distribution and displacement in the Earth's crust. This research involved the study of soil cross-sections of sedimentary rocks, and of plants and animals. The Soviet scientist demonstrated the effect of the chemical composition of the soil, and of sea, river and other waters on the changeability and adaptability of the plant and animal kingdoms. High crop yields, the health of man and of domestic animals depend most directly upon a number of chemical elements in the environment. An abundance or lack of some of them produces various biological reactions on the part of the animal organism and in the final analysis causes endemic diseases. For example, in districts where an abundance of fluorine is present in the soil, men as well as animals suffer from fluorosis, a softening of the teeth. Cereals do not ripen if there is a shortage of copper in the soil, and this shortage causes a special form of anaemia in animals, etc., etc.

It will be of interest to note that the widespread concept attributing the cause of goitre to the lack of iodine in drinking water has been disproved by these investigations. The ordinary content of iodine in fresh water is one milligram per litre, whereas man's daily requirement of this element approximates 120 milligrams. Consequently the bulk of iodine is ingested

with food. If the soil does not contain iodine, it will be absent in drinking water as well as in the food.

The investigations of A. Vinogradov have introduced essential corrections also into the data on the percentage of chemical elements in the terrestrial crust on the territory of the USSR. They have made it possible to concretise our concept of the ratios of different chemical elements. The Soviet scientists have shown that the fluctuations in the ratio of elements with related physical and chemical properties (for example, the binaries: chlorine and bromine, zinc and cadmium, niobium and tantalum, nickel and cobalt, strontium and barium, etc.) caused by various geochemical processes, are smaller than in other arbitrarily chosen combinations of these elements. It is therefore possible to judge by the amount of one element the probable content of its related element under given conditions.

The deep ties between science and practice characteristic of all the trends of scientific thought in the USSR, may well be illustrated by the interesting "convergence" of the closely related sciences of geochemistry, mineralogy and petrography. These sciences are concerned in the main with investigations of the processes of formation of minerals in the Earth's history. Understanding the essence of the different processes in the formation of minerals and the links between the consecutive stages in these processes, Soviet investigators have confidently based their search for minerals on various, often indirect symptoms.

However, thorough theoretical and experimental studies of complex natural compounds have also enabled the investigators to predict in advance the properties of one or another mineral body of a definite composition formed under different conditions. They used this information for reconstructing, at first in the laboratory and later in the factory, the conditions

attending the formation of minerals decoded from the example of natural compounds.

Thus was a new industry born: the production of artificial stones which constantly provides new materials for technical purposes. The school of Soviet petrographers, which was headed by the late Academician D. S. Belyankin, has succeeded in founding a new field in stone casting technique. The production of numerous fireproof materials—exceptionally strong tiles for facing buildings, chemical containers which resist the action of any acids, etc.,—from molten rock subjected to definite treatment, or from metallurgical slag, has been developed in the USSR on an industrial scale.

Continuing the investigations of litho-mechanics, Professor Kitaigorodsky created entirely new ceramic materials used, for example, for producing metal cutters which endure a speed that would immediately destroy cutters made of the toughest steels.

Geochemistry has before it many important problems relating to the origin of the Earth, its evolution, structure, radioactivity, displacement and accumulation of elements in different strata of its crust.

“There can hardly be any doubt,” pointed out the President of the Academy of Sciences A. Nesmeyanov, “that the next to develop after geochemistry will be cosmochemistry which investigates the generation of elements, and their rotation on a cosmic scale.”

One cannot but recognise that this statement is justified. The science of the future, cosmochemistry, is already making itself known by its interesting deductions.

Ever since the investigators have acquired a method of studying the chemical composition of the Sun's surface strata, they have been astounded by its likeness to the chemical composition of the Earth. This would seem to substantiate their ideas that the

matter constituting the planets was derived from the Sun. Data on the quantitative chemical composition of many stars and nebulae obtained in recent years also revealed remarkable features of likeness. This is one of the manifestations of the material unity of the Universe. The revolution of various celestial bodies represents, as the Soviet scientists believe, separate links in the eternally uniform process of the evolution of matter. Different links of this single chain have been explored to one or another degree. But does it mean that we must adhere to a mechanical consistency in their cognisance? Indeed, not! The history of science shows that local problems are likely to be investigated earlier than general problems. This is the usual course in the development of science.

The question of origin of the primary cloud from which the Earth and the planets have originated is still being debated. Cosmogonists are combining efforts with geochemists in order to find, in the light of the new theory of the Earth's origin, a new interpretation and to acquire a deep knowledge of the specific features of the Earth's structure.

And on another sector of its wide front Soviet science is already making a bold thrust forward with the object of penetrating into the secret of the origin of life on Earth.

The Origin of Life

THIS IS NOT A narrow problem confined to biology; it is closely associated with physics, chemistry, astronomy, geology and other natural sciences. The question of the essence and origin of life, which has always excited man's imagination, was approached from different angles in different epochs and at different stages of progress. Here, too, passed the dividing line between bold materialist thought which leans on the

objective laws of nature and the timid attempts to evade direct answers and withdraw to the shaky domain of agnosticism.

In essence, the controversy has always revolved around the question whether life, like the whole of the Universe, has its origin in matter or in some spiritual source of which knowledge cannot be gained by experiment. This is by no means an abstract dilemma. If life is material (and this is the viewpoint of Soviet scientists), then it is possible and necessary, by studying its laws, consciously to alter and transform living organisms in a given direction. If life is the product of a spiritual source and its essence is unknowable, then we are doomed to be passive observers of living nature which has not changed throughout the ages and cannot be changed.

For a long time the question of the origin of life, one of the most difficult scientific problems, found no support in the natural sciences. The later stages in the evolution of life on Earth have been comparatively more thoroughly studied. A study of fossil remains of animals and plants which populated the Earth in times long past convinced us that many million years ago the Earth had a different population than today. Looking back into the centuries we found constantly simpler and less varied forms. It is generally accepted now that not only contemporary plants and animals but also man himself have evolved from less organised and simpler beings. But the question of the origin of the simplest, primary forms of life on Earth remained obscure for a very long time.

Soviet scientists approach this burning problem as materialists convinced that, as it rises from lower to higher stages of development acquiring more and more complex and perfected forms of movement, matter acquires new qualities which did not exist earlier. And life itself is a new quality originating as

a definite stage in the history of the evolution of matter. "The main and reliable way to the solution of the problem of the origin of life," says the Soviet investigator of this question, Academician Alexander Oparin, "lies through the study of the history of the evolution of matter. This evolution has led to the origin of a new quality, the origin of life." On the basis of this premise Academician Oparin has undertaken to trace the course of transformation and development of matter back to the times when there was no life on Earth.

To our regret we are unable in this brief survey to follow Academician Oparin through all the stages of his investigations, and we shall confine ourselves to the most important ones.

What can be more fascinating than the adventures of human thought in the realm of the unknown! In order to substantiate his views, Academician Oparin had to turn to the celestial bodies. But what could he seek there? Carbon compounds—the fundamental element around which all the other component elements are grouped in organic substances. The scientist was prompted to turn to the "celestial laboratory" by his desire to be able to judge, on the basis of facts, about the transformations of carbon at the time of the formation of the Earth, at the initial stages of the evolution of our planet. A chemical analysis of the Sun's surface indicates that some carbon compounds exist even under the temperatures prevailing there. Investigations of "celestial rocks," or meteorites, revealed the presence not only of carbon (mainly in combinations with metal), but of hydrogen as well. It was here that Oparin's concept came into its first—but not the only!—contact with the new theory of the formation of the Earth mentioned above. According to Schmidt's theory, this approximately was the state of the basic mass of carbon which went into the making of the Earth. Apparently, at the early stages of the evolu-

tion of our planet, carbon and iron compounds which even today escape from the depths of the earth's crust to the surface, could constantly interact with surface strata and even come in contact with the Earth's atmosphere. The interaction of these compounds, the carbides, with the water and the water vapours in the atmosphere, led to the formation of compounds of carbon and hydrogen, i.e., hydrocarbons. Have not traces of this titanic process remained in the atmosphere of Jupiter and other big planets?! In the process of further evolution these primary hydrocarbons gave rise to complex compounds similar to those we now call organic. The chemical possibilities inherent in hydrocarbons are generally known. In the modern laboratories they serve as the basis for the artificial production, the synthesis, of almost all the complex chemical compounds which go to make up fats, sugars, dyes of different shades and various flavours and perfumes. With the aid of ammonia and hydrocarbons as a basis, chemists produce complex nitrous compounds.

Reference to the modern laboratories with their complex equipment might seem inadequately convincing. But there are numerous examples in chemical practice of the origin of various organic substances in very simple conditions, even in ordinarily preserved water solutions of hydrocarbons and their derivatives. Highly convincing proof is furnished also by the experiments on the synthesis of protein-like substances under pressure, carried out by the Soviet chemist Bresler in Leningrad. He has succeeded in accomplishing these syntheses under pressures which could quite probably arise in the depths of the ocean. These experiments leave no room for any doubt that amino-acid "bricklets" of which complex protein molecules are built, could and did arise under the conditions prevailing in the primeval seas. These "bricklets" are

in their turn composed of thousands, nay, tens and hundreds of thousands of atoms of carbon, hydrogen, oxygen and nitrogen. Thus has Academician Oparin defined the next decisive stage in the evolution of matter towards the origin of life. It is the stage of the formation of proteins in the chemical concept of this term.

It will be in place here to digress somewhat from the subject so as to characterise the foundation from which generalisations of this kind spring. This foundation is the development of a new branch of knowledge—biochemistry, at the junction of physiology and organic chemistry. Academician Oparin, a pupil of A. N. Bach, heads the school of biochemistry in the USSR. This school, like all the other advanced scientific schools in the Soviet Union, is developing on the basis of the harmonious union of theory and practice. Theoretical generalisations are born in the process of researches which are of urgent importance for the life of the country. And theory itself, as it gathers strength, facilitates the speediest and most successful solution of problems raised by life.

We have just mentioned the efforts of Academician Oparin to make a mental excursion into the secrets of the origin of vital processes. This soaring flight could be attempted only by thought armed with an understanding of the essence of vital processes in all their complexity and diversity. Foreign biochemists who adhere to metaphysical idealist concepts, ascribe to mythical immutable genes the role of governing metabolic processes which, properly speaking, constitute the characteristic feature of life. Soviet biology has counterposed to these idealist concepts, a real, scientifically-consistent materialist explanation of vital processes based on concrete experimental data.

Let me cite as an example only one tendency in these investigations, namely, the study of the primary

role played in all these complex manifestations of life *by special substances called enzymes.* Along with vitamins and hormones they constitute the group of compounds which direct all the changes lying at the basis of metabolism in the living organism. Enzymes are the real keys to life. All component substances of the organism—phosphorous compounds, fats, carbon-hydrates, etc.—would be inactive if they were not influenced by enzymes. Without the digestive enzymes starch would be converted into sugar not in ten minutes, as it is in our body, but in scores of months. Without respiratory enzymes, the organism would be doomed to death from asphyxiation even in an atmosphere of pure oxygen. It required immense efforts to study the nature of enzymes, but the practical results were extremely important. By discovering the effect of enzymes on the quality of bread, Academician Oparin laid the foundation for a new technology of bread-baking. He recommended simple and convenient methods which make it possible to determine in the space of several minutes whether the dough mixed of flour of one or another quality will produce a light or heavy, a porous or compact loaf. Employing the methods recommended by Academician Oparin, Soviet bakeries are mixing various grades of flour so that the properties of their enzymes might supplement each other. The mechanised bakeries of the USSR turn out daily thousands of tons of bread.

One of Academician Oparin's collaborators, Boris Rubin, created, on the basis of his investigations of enzymes, a uniform theory of fruit and vegetable storage which vegetable and fruit growers throughout the Soviet Union are now guided by. For every kind of root crop or fruit variety conditions of winter storage are created which arrest enzymatic activity in them to a certain degree yet at the same time sustain their resistance to bacteria.

Another research worker of the Biochemistry Institute of the Academy of Sciences of the USSR, Norair Sisakyan, disclosed the biochemical nature of drought-resistance. He revealed the dependence of a plant's capacity to resist drought on the action of enzymes. Depending upon the conditions, these remarkable substances which accelerate all the processes at work in every organism, are present in cells either in the bound or in the free state. Correspondingly they play either a constructive or a destructive role. Their destructive effect is manifest during drought when the plant cells lose much moisture. This discovery has helped N. Sisakyan to find a simple method for determining the capacity of a plant to resist drought and dry winds. These experiments are as simple as they are effective: by drying the leaves we subject them to approximately the same action as that of a dry wind in natural conditions. Then, through analysis, it is possible to determine to what degree the destructive forces of the enzymes have been released in it. The possibility is thus opened for judging the drought-resistance of a plant by its first shoot. This will completely revolutionise the work of plant breeders by simplifying the laborious process of selecting and testing seedlings. Continuing his research, N. Sisakyan discovered the predominant influence of various enzymatic systems, which determine the trend of metabolism, on other most important properties of plants—not only on their drought-resistance, but also their resistance to frost, their productivity, ripening period, etc. An understanding of the laws governing the changes in the activity of enzymes enables the scientist directly to intervene in the biochemical process upon which the biological properties of the organism depend. A solid foundation is thus furnished for plant hybridisation. The thoroughly substantiated aim before it is to create new biochemical properties that will be fixed in the

offspring raised from seeds and inherited by the next generation.

But let us return to Oparin's theory which traces the origin of life on Earth. Where in the remote prehistoric past has the investigator discovered the leap, the qualitative change which characterises life as a special form of movement of matter? The qualitative distinction of life is most vividly manifest in metabolism. The substance of the living organism is not static. It is in a process of constant disintegration and regeneration as a result of the numerous closely interconnected reactions of decomposition and synthesis. A specific feature of living substance, as already mentioned above, is the directed, organised and law-governed nature of these transformations. The exceptional role of proteins stands out most conspicuously.

On the basis of his study of the conditions that developed in the waters of Earth's primary hydrosphere where, along with other complex organic substances, protein-like compounds were formed—and through direct experiments of isolating and settling from general solutions coacervates (distinctly outlined drops) that can be already detected by the microscope, Oparin reconstructed the picture of the formation of these complex systems. "Prior to that moment," he writes, "organic substances were evenly distributed, dissolved in the waters of the primeval seas and oceans, in the primary hydrosphere of the Earth, and inseparably blended with this hydrosphere, with their environment. When coacervates were formed, the molecules of various proteins were condensed, combined into complex compound systems which emerged from the surrounding solution in the shape of drops. Each drop exists as a definite individual formation with its own specific structure and separated from its environment by a definite boundary. Only this emerging of complex protein systems could create the dialectical unity of

the organism and its environment which was the decisive factor in the process of the origin and evolution of life on Earth."

The analysis of these systems is the most fascinating side of Oparin's investigations. The structure of the primary coacervate drops was comparatively simple, but they gradually acquired a more and more complex and perfect structure until they were finally transformed into primary living things, the progenitors of all life on Earth.

How did this remarkable transmutation take place? Oparin answers this question as follows: any change in the coacervate drop under the action of the environment prevailed only if it contributed towards the dynamic stability of the coacervate. Therefore, along with the increase of organised matter, with the growth of the coacervate drops, the quality of the drops themselves changed constantly in a definite direction. The order of chemical processes could be altered only in such a way as to ensure the preservation of the system as a whole. Failing to meet this condition, the given coacervate drop lost its dynamic stability and was doomed to destruction. Sooner or later it was bound to disintegrate and vanish. "This was how the coordination, the adaptedness of inner structure to fulfilling vital functions in a given environment developed which are so characteristic of the organisation of all living things," writes Oparin.

What was the structure of these primeval living things? Here is what Oparin says in this connection: much more perfect than the coacervate drops, but nevertheless simpler than the simplest beings known today. At any rate, cell structure was still absent at that stage. It appeared at a much later stage in the evolution of life.

In this point Oparin's consistent theory was until very recently at variance with the widely current con-

cept of cell structure being the primary foundation of all life. The theory of Virchow, who advanced the formula which for many decades was considered unshakeable, namely, "Omnis cellula e cellula," ("every cell from a cell"), commanded almost universal recognition. The opponents of Oparin's theory saw its main shortcoming in the absence, as they believed, of the most important link: the history of the origin of cell structure. And, indeed, there was a distinct gap which could be bridged only on the basis of new facts, because precisely facts represent the air in which theory soars. A stream of new discoveries has not only scattered all doubts with regard to the exhaustive completeness of Oparin's theory of the origin of life, but caused a revolution in modern cytology (the science that treats of cell structures), physiology and medicine. I have in mind the discovery of Professor Olga Lepeshinskaya who proved that cells originate also from non-cellular living substance, a possibility which was formerly denied.

Living Substance

VIRCHOW'S FORMULA, "the cell originates only from a cell," leads to the negation of the general laws governing the development of life and its progress from the simple to the complex, from lower to higher forms. This precisely is the point of confluence of Virchowism with the theories of Weissman, Mendel and Morgan proclaiming the principle that the "hereditary substance" is immutable and that its changes are independent of environmental influences.

Professor Lepeshinskaya made a study of the wall of animal cells with the object of discovering changes caused by age. Though a modest aim in itself, it was held by many to be a bold attempt, because the very possibility of cell development was widely denied

theretofore. The concrete object studied by Lepeshinskaya through the microscope was the cell-wall of frog erythrocytes (blood corpuscles) at different stages of development. Observing through the microscope the blood of a tadpole, the scientist discovered and studied in detail the various stages of transition from the yolk globule, i.e., the pre-cellular form, to the cell. She had before her fascinating pictures of the development of blood from yolk globules, i.e., a substance which lacks a cell structure. These pictures and the bold deductions drawn from observations of the new phenomena are recorded in O. Lepeshinskaya's monograph, "The Origin of Cells from Living Substance and the Role of Living Substance in the Organism."

It required great courage to believe in the obvious, so sharply did it depart from the established, generally accepted views. Perhaps more than once had pictures of this kind passed before the vision of astonished investigators who would begin to fumble furiously with the fine adjustment screw, suspecting an optical delusion.... It required still greater courage on the part of the investigator to check critically and painstakingly her own initial observations in an atmosphere of hostile distrust: the cell theory dimmed the vision of many a scientist and obscured the future paths in science! "It is hard to estimate," the scientist told later, "how many hours, days, weeks and months had passed before my collaborators and I succeeded in following up the development of scores of cells from the yolk globule to the cell of a germ layer or to the erythrocyte and its blood." Incontestable experiments—hundreds of them!—furnished proof that cells arise not only in the process of division of the fertilized egg cell, but that they also develop directly from the yolk. But how were others to be convinced of this? The investigator called to her assistance an objective witness, the movie camera. The slow-motion camera made

it possible to show the whole "biography" of the cell from the yolk globule to normal division.

O. Lepeshinskaya's works not only made it possible completely to refute all the theses of Virchowism which had predominated for such a long time in the biological sciences but also enriched biology with new fundamentally important facts, thereby opening great prospects for the progress of theory in literally all the branches of biology. We shall touch only upon some of the endeavours of the Soviet scientists to illustrate this.

Self-Renewal and Regeneration of Tissues

UP TILL NOW all the processes that take place in the fine structures of the organism, its tissues, were associated only with the cellular form of organisation of living substance. All these processes in the tissues which lie at the basis of the endless variety of vital functions in the multi-cellular organisms were attributed entirely to cellular processes and their investigation was regarded as the only key to the solution of all the fundamental problems of histology. No one thinks of denying the importance of a thorough investigation of normal cells. This work must be and is continued. But Soviet scientists have realised that it is high time to widen the range of experiments in this field.

An essential problem in this sphere is the regeneration of tissue. One of the greatest services rendered by the Soviet scientists lies in that they have firmly established the view that the tissues of a multi-cellular organism are not static, immutable structures, but are in a state of continuous development. They are constantly worn out in the course of their vital activity, and then continuously renew, regenerate themselves. This is not a process of "eternal repetition." At every stage in the development of an organism, the regenerat-

ing tissues acquire new properties and qualities. There is, for example, a distinction between the continuously self-renewing blood of animals of different ages. Such distinctions are characteristic of all the tissues in higher animals. It has led Soviet investigators to the important conclusion that the self-renewal of tissue cannot be looked upon as a process of reproduction of "like" tissue elements only, but also as a process which leads to the development of qualitatively new properties in tissues at different stages of development. At any rate, the process of continuous regeneration of tissues cannot be reduced only to a perpetual process of cell multiplication.

The new theory furnished the mainstay for explaining many processes of tissue-building, the processes of their qualitative alteration resulting from continuous self-regeneration. Investigations conducted for many years by Professor Georgi Khrushchov and his collaborators confirmed his earlier hypothesis that qualitatively new tissue elements may arise not only as a result of cell division, but also through new formations of non-cellular forms which in the process of development engender new cells of the respective tissue.

Professor Khrushchov used certain teleosts as experimental material in his investigations of the regenerative processes in tissues. During the experiment the fish were kept hungry for a length of time, whereupon a return to optimal nutrition accelerated the processes of tissue regeneration. These experiments led to a remarkable discovery: at the stages of the highest intensity of the regenerative processes in the intercellular substance of the loose connective tissue, which was the main object of study in Professor Khrushchov's experiments, the formation of living protoplasmic bodies with amoeboid movements was observed near the small vessels, i.e., in places where metabolism

was most intensive. These bodies accumulated rapidly around the vessels. Observations of the gradual process of tissue regeneration made it possible to detect the development of these protoplasmic bodies from the tiniest, simple, drop-like formations to the complex pre-cellular stages—to bodies with a separate nuclear substance.

Operating with entirely new material, Professor Khrushchov proved that in the process of regeneration and, consequently, self-renewal, tissues may arise not only as a result of cell division, but also from new non-cellular living substance arising *de novo* outside the cell. The investigator believes that the qualitatively new cells, which differ from the hitherto existing tissue elements, are not descendants of these elements resulting from their multiplication, but that they represent new formations springing from a qualitatively new living substance synthesized by the organism.

In the Biochemistry Institute of the Academy of Sciences of the USSR, different stages in the development of living substance, beginning with the simple proteins, were thoroughly investigated with the object of establishing the specific laws governing metabolism in different structures. These investigations, too, have led to the discovery of new facts which contribute to the development of the theory of non-cellular forms of living substance. The eminent Soviet biochemists Sisakyan, mentioned above, in cooperation with Kuranov, established, for example, that in the metamorphosis of the mulberry silkworm-regular, well-coordinated enzymatic processes of metabolism, attended by rapid protein synthesis, arise in the non-cellular fluid of its body cavity.

These experiments confirmed the general formula arrived at by Professor Lepeshinskaya on the basis of all her numerous investigations: "Living substance is capable of assimilating the external environment and

developing into cellular structures." This formula has gained wide recognition among Soviet biologists. Ideologically it coincides in full with the main principles of materialist biology. A major contribution towards the development of this biology was made by the great transformer of the nature of plants, Ivan Michurin. The Michurin science holds that the living body and its environment invariably constitute an integral whole.

At the present juncture, when the new theory is finding wide application in daily scientific endeavours, this general formula will unquestionably be given more concrete definition. An example is furnished by the latest research of Professor Alexander Studitsky, who has not only investigated theoretically, but has also accomplished in practice the regeneration of injured animal organs and tissues. In line with the principles of materialist Michurin biology, he studied the regenerative processes not as a manifestation of the properties of individual tissues, but as a regular reaction of the whole organism to the injury. This reaction, like all the other reactions of the organism, is an adaptation to the conditions of life.

The more perfect an organic structure, the more intense its functions, and the greater is its regenerative reaction, declares Studitsky. To prove this thesis which upsets all the accepted views on the question, Studitsky performed experiments on birds.

The scientist began with a study of the regenerative reaction of the bird's organism to the removal of whole bones from its skeleton. It was found that not only in birds but in some mammals, too, this reaction is very strong. Studitsky managed to restore whole bones in a living organism. Then he passed over to experiments on tissues. Here, too, he had to overcome conservative ideas which seemed to find support in the whole practice of surgery. The growth of the injured muscle fibres in a wound is usually the only regene-

orative reaction of the organism to an injury of muscle tissue. But even these fibrous growths are shortlived: they are doomed to die sooner or later, and the injured spot is filled by a connective tissue scar....

Studitsky conducted bold experiments on the biceps (double-headed arm muscle) of young cocks and hens of different ages, and found the development of real muscle tissue composed of contractible fibres which flex the wing of the chick.

It became clear that if the process of regeneration of injured muscles was not observed hitherto either in the laboratory or clinic, it meant that both experimenters and surgeons failed to take into account the conditions necessary for the regeneration of injured organs. What are these conditions?

Studitsky explained these conditions and thus disclosed the secret of controlling the regeneration of muscles. It appeared that the initial stage of regeneration of muscle tissue is characterised by the development of cells called myoblasts from a living substance formed as a result of the disintegration of the injured muscle fibres. The investigator intervened in this process. He cut up a severed muscle into fractions and reduced it into a homogeneous semi-liquid mass. Then he grafted this pulp in place of the severed muscle and observed a remarkably accelerated development of the new formation.

The human organism lacks the capacity of regenerating severed limbs. Even in times long past, neither man nor his mammal ancestors, had ever experienced injurious effects which would tend to develop this property. But investigations of the regenerative reaction of mammal organisms to injuries of all the materials of which their organs are built, inspire the hope that the artificial development of this property may prove possible.

The practical results bound to arise from these highly significant researches are by no means a thing of the distant future. Encouraging data already obtained point to the successful treatment of wounds with living substance taken from the organism, and, in particular, from the tissue around the wound. It is supposed that the formation of a cancerous tumour is preceded by a change in metabolism which leads to the development of pathological living substance. We may perhaps look forward to the early discovery of new possibilities of influencing qualitative changes in metabolism with the object of preventing the formation of abnormal, malignant, pre-cancerous living substance....

But let us turn back from the fascinating prospects of the science of tomorrow to its current achievements.

In the Name of Life

ONE ESSENTIAL MOMENT in A. N. Studitsky's experiments mentioned above directs our attention to a most important link in the theory of the living body—the physiological teachings of the great Pavlov. The main condition for the complete regeneration of a muscle in Studitsky's experiments was the rapid development of nervous activity. The new muscle tissue acquired its function and began to work only after nerve filaments had grown into it. This important fact is a reminder that the investigator can count on complete success only if he is able to connect the evolution of living substance in the organism with the functions of the nervous system. The concept of these functions in Soviet science is extremely broad, in line with the theory of Pavlov who proved that the cerebrum controls all the processes in the body. In the light of this most important law of physiology, experimenting physiologists and practical clinicists are now re-examining

the work of all the systems and functions of the organism.

We shall touch only upon some aspects of Pavlov's theory of conditioned reflexes and illustrate by a few examples the influence of Pavlov's ideas in medicine.

This growing influence is in perfect harmony with the efforts of the great physiologist to connect theory with practice, to investigate phenomena and to control them. "If the doctor is in reality, and still more in ideal, a mechanic of the human organism," wrote Pavlov, "then every new physiological achievement must not fail sooner or later to strengthen the doctor's power over this extraordinary mechanism, the power to preserve and repair this mechanism." The goal which inspired Pavlov is being achieved: the development of his theories equips medicine with the means of elaborating scientifically-substantiated therapeutic and prophylactic measures. Relying upon Pavlov's theories, Soviet medical science is wresting itself free from the misleading one-sided concepts of the essence of disease as an expression of the special "pathological" constitution of the organism.

In the question of pathogenesis, Pavlov's theory lays chief stress on disturbances in the normal interaction ("balance") of the organism and its environment, and thus provides guiding directives for the prevention and treatment of diseases. It will not be amiss to note in this connection the remarkable achievements of Academician Alexander Speransky and his school in investigating the action of extraordinary irritants, the pathological reflexes they rouse, and the general problem of interconnection of pathological reactions proper and protective reactions. The group of researchers directed by Speransky concentrated their attention mainly on the role of the higher departments of the cerebrum in processes of disease and compensation. Interesting results were also achieved

in the search for pharmacological methods of influencing the central nervous system.

There was a time when Soviet scientists criticised a number of erroneous concepts entertained by Speransky (his idea of the nervous network, etc.) which were due basically to an underestimation of the significance of studying the fine physiological mechanisms underlying the development of morbid conditions, and to the inadequate use of the wealth of Pavlov's physiology. Academician Speransky took note of the critical remarks addressed to him in order to reconsider a number of important questions in a new light and to obtain a great many new facts.

This example is very instructive. It shows how deeply-rooted in Soviet science and medical practice is the idea that it is impermissible to study only local morbid phenomena in an integral organism without taking into account its general reactions. Soviet medical specialists have recognised the need for giving the most careful attention in each case to the specific nervous reaction of the patient, to the effect exerted by disturbances in the higher nervous activity on the origin and progress of disease. Promoting the application of Pavlov's ideas in medical practice, Soviet medical specialists take full account of the principle of the unity of "psychic" and physical functions, and even in cases of many internal disorders they employ methods of disease prevention and treatment which tend to regulate nervous and psychic functions.

Here, as in all other spheres of Soviet science, advanced ideas and methods are not confined to a small group of special clinics or laboratories. The initiative in the development and practical application of a number of basic ideas of Pavlov's theories has come from many ordinary workers of the Soviet health service. Reference may be made, for example, to the practice of the doctors of the Makaryev hospital in

Kiev Region. They used Pavlov's idea about protective inhibition of cortical activity to eliminate various irritants of the environment (light, sound, etc.) which had an unfavourable effect on the progress of many diseases. To this end, they had to alter radically the traditional hospital regimen and to work out new "soothing" principles of organising the environment of the patient in the hospital. Commenting on this initiative of the attending physicians, the President of the Academy of Medical Sciences, Academician Anichkov, justly hailed it as one of the most striking manifestations of the socialist humaneness of Soviet medicine which leans on Pavlov's ideas.

A convincing example illustrating the great importance of Pavlov's ideas in medical theory and practice is afforded by the change in the views on the pathogenesis of such a serious and widespread disorder as ulcer.

The prevailing view in medicine a quarter of a century ago was that ulcer of the stomach and the duodenum was a local disorder in these organs. Theories changed, but their substance remained invariable: the development of ulcer was viewed apart from a number of external factors, and from digestion in the stomach in particular. Only Pavlov's theory of the interplay of the processes at work in the stomach and of higher nervous activity, i.e., of the functions of the cerebral cortex, further developed by his pupil, Academician Bykov and his school, supplied the key to an understanding of the origin of ulcer. It was found that ulcer is caused by a disorder in digestion in the stomach resulting from special disturbances in the "cerebral cortex-stomach" system. Changes in this system due to the action of unfavourable external conditions of nutrition and digestion may lead to an ulcer of the stomach. The new views led to the abandonment of the naive methods of combating the ulcer

employed in the past. The latest tendency in medical practice has been to employ nerve-soothing therapy and a proper diet in the treatment of this disorder. Especially favourable results in the treatment of ulcer have been produced by the induction of prolonged sleep which, to use Pavlov's terminology, ensures "protective internal inhibition." It is worth dwelling specially on this method.

According to the concepts of the Pavlov school, sleep is the widespread inhibition of cortical functions. It may therefore be used in the treatment of diseases brought on mainly by abnormal nervous reflexes with resulting peripheral disturbances in vascular functions, in metabolism in the tissues, secretion, etc. Lying at the bottom of many diseases of man is a direct over-exertion and exhaustion of the cerebral cortex, and its consequent weakening as the centre that regulates the vital functions of the different organs. Sleep is employed by doctors to eliminate this over-exertion and exhaustion. Developing Pavlov's ideas, Soviet scientists and doctors have begun to apply prolonged sleep, induced by means of drugs and conditioned reflexes, in the treatment of psychic disorders (the pioneer of this method was Professor Ivanov-Smolensky, a pupil of I. Pavlov). A substantial contribution towards the development of sleep therapy was made by another pupil of Pavlov, Professor Ersas Asratyan. On the basis of numerous and varied experiments, this scientist elaborated new principles of sleep therapy, in particular, in the treatment of traumatic lesions in the human nervous system. The method of sleep therapy proposed by Professor Andreyev is also finding wider application in Soviet medical practice.

Attaching special importance to the environment and its influence on pathogenesis, Soviet medical science lays great stress on the development of all prophylactic branches of medicine and the application of

their achievements in medical practice. The most harmful disease-causing agents of the environment are the pathogenic micro-organisms. The President of the Academy of Medical Sciences of the USSR, Academician Anichkov, said in one of his reports that the successful work of the medical research institutions and health departments of the USSR has made it possible to check such extremely contagious epidemic diseases as enteric and typhoid fever; smallpox may be considered an eradicated disease. Thoroughly elaborated and scientifically substantiated measures against malaria have made it possible in recent years greatly to reduce the incidence of this disease.

Academician Anichkov credits this success in combating infectious diseases largely to the antibiotics and new chemotherapeutic preparations evolved by Soviet scientists and adopted in practice. He classes among them such preparations, for example, as synthomicin and albomicin which produce very favourable results (arrest the growth of germs) in dysentery, pneumonia and suppurative inflammation of the middle ear.

It is impossible to crowd into a brief review even a mere enumeration of the new medical preparations proposed and tested of late by Soviet scientists. We should, however, dwell on one of them. A problem on which attention of medical specialists throughout the world has been focused for decades is that of combating tuberculosis, one of the diseases most difficult to cure. Medicine has in recent years dealt a few hard blows to this terrible enemy. The great hopes roused originally by the appearance of such important anti-tuberculous preparations as streptomycin, para-aminosalicylic acids (PAS), tibon and others were not fully justified, but the method of their application is being continuously perfected and in some cases their competent use has yielded splendid results. The latest weapon in the struggle against tuberculosis forged in

the laboratory of the Ordjonikidze Chemico-Pharmaceutical Research Institute is phtyvasid. Clinical tests have shown it to be a powerful agent in the treatment of different forms of pulmonary tuberculosis. The new preparation has also been successfully employed in treating tuberculosis of the larynx and other sections of the respiratory tract, and in tuberculosis of the skin (lupus), of the lymphatic glands, kidneys, bones and joints. It is taken internally in the form of powders or pills. Nevertheless, Soviet medical specialists do not counterpose phtyvasid to other preparations employed successfully in the treatment of tuberculosis. Different preparations have a different effect on various aspects of the metabolism of tuberculosis microbes and penetrate the seats of tuberculosis in different ways. It is not surprising therefore that in combination they yield the best results.

Inasmuch as we have touched upon the action of drugs, it should be noted that the study of this action is one of the most important factors in the preparation of new remedies in the USSR. This is a highly organized process, removed very far from blind groping through empirical tests. An eminent representative of this branch of medical science which is concerned directly with the investigations of the fine mechanisms of drug action is Professor Pershin. He carried out a number of investigations to study the effect of bacteriocidal and chemo-therapeutic preparations on bacterial enzymes. This brought to light the enzymatic reactions whose disturbance determines the bacteriocidal effect. The results of his investigations have led Professor Pershin to assume that the antimicrobial action of chemo-therapeutic compounds depends on disturbances in the processes of biosynthesis in the microbe cell. Hence the direct way towards the conscious quest for substances which disturb this synthesis.

It requires, of course, long and painstaking research to cover the way from these fundamental theses to the preparation of one or another drug. Thus, for example, a group of workers of the institute where phtyvasid was prepared (Professor Pershin among them) synthesised more than 640 compounds. Their action on the tubercule bacillus has been studied. Numerous tests revealed the most effective compounds which disturb the metabolism of the tubercule bacillus without injuring the human organism. The most effective preparation selected among them was called phtyvasid.

The steadily rising living and cultural standards of the population and the measures taken by the Soviet State to promote municipal improvements and sanitation, afford most favourable conditions for the application of the principle of disease-prevention which is the fundamental factor in Soviet medicine. The success of disease-prevention has been greatly facilitated by new improved methods for the mass production of effective vaccines and their rational preservation elaborated by Soviet scientists. The use of these vaccines for prophylactic inoculations brought about a sharp decline in the incidence of many contagious diseases. Noteworthy in this respect is the work done by the Gamaleya Institute of Epidemiology and Microbiology of the Academy of Medical Sciences of the USSR. The new method of fine separation in the preparation of immunizing serums developed at this institute has made it possible to increase considerably the production and to improve the quality of these serums. In the past, for example, 10,000 units of diphtheria antitoxin serum were injected in the amount of 20 cubic centimetres, whereas today this volume has been reduced to 2 cubic centimetres. The prescribed dose of antitoxin serum in the case of tetanus is only one-tenth of the old dose. The reduction in the volume of the

serum is possible owing to the greater reduction of its protein ballast. The staff of the institute has built an original apparatus for the vacuum drying of such valuable preparations as, for example, the small pox vaccine. Dry vaccines may be preserved for a long time and shipped over long distances.

It is impossible within the limits of this review to touch upon scores of other achievements of Soviet medicine: tissue therapy, effective measures for combating states of agony, etc., etc.

Power Over Nature

WHEN WE SAY that Soviet medicine with its scientific foundation as represented by Pavlov's principles, its powerful social and economic backing, as represented by the state provisions for a secure old age, the vast system of sanitation, disease-prevention and clinical services, rest homes, sanatoria, etc., has advanced far beyond the limit of "protective" tasks, this should be understood in a very broad sense. Its purpose is not only to combat one or another malady, but to battle on a wide front against premature old age, to battle for longevity. One cannot fail to see in this a manifestation of the fundamental tendency of the socialist society, its greatest humanism and social optimism.

These social features of our system are active factors in the struggle against the misanthropic ideology which is inevitably brought into play wherever there is need for justifying oppression and the poverty of vast sections of the population engendered by the abnormal nature of social relations. One hundred and fifty years ago, the Reverend T. R. Malthus, Professor of Political Economy in the College of the East India Company, built a "theory" depressing for its pessimism; its main thesis is that population tends to multiply faster than its means of subsistence can be made to do.

It is for this reason, explained Malthus, that the vast majority of the earth's population cannot partake in the "feast of life." This pseudo-theory, revived and supplemented by racist fables, is widely employed to this day for justifying the oppression and exploitation of the people at home and in foreign countries. Both the Malthusians of old and their contemporary followers have sought support for their misanthropic ideas in the "law of diminishing returns" invented by bourgeois economists. This notorious "law" is a very convenient instrument for the ideological disorientation of the plain people. By representing this "law" as all but a "law of nature," the Malthusians obscure from the people the real obstacles raised by the capitalist economic system in the way of the progress of agriculture.

Even before the Revolution, advanced Russian science, noteworthy for its progressive democratic tendencies, furnished convincing arguments against the "law of diminishing returns." Russian scientists developed effective scientific methods for raising the fertility of soils. Their strivings were aptly expressed at the beginning of our century by the great Russian naturalist, K. A. Timiryazev, in the brief formula: "two ears of corn will grow where only one grew before." A pre-eminent authority on plant physiology, Timiryazev was at the same time a public figure with the broadest vision. He was well aware that a high level of science alone is not enough for making this lofty dream come true. It requires also the possibility for the rational use of the achievements of science in the interest of all the people and not of a small profit-seeking minority.

The "problem of two ears of corn" has been solved in the Soviet Union: in 1952, when some areas were drought-stricken, the tillers of the Soviet fields garnered 8,000 million poods of grain (1 pood equals 16

kg.), which was double the crop harvested in pre-revolutionary Russia in the most favourable years. The crop was doubled although the area cultivated to cereals was expanded only by 5 per cent. The collective farms and state farms have also well advanced the production of technical crops, and, notably, cotton. The gross cotton crop in the USSR in 1951 was 46 per cent above prewar, the average per-hectare yield in the main cotton-growing areas of the country rising to 2.1 tons per hectare, which was more than 2.5-fold the cotton yield in the USA.

This is a major success. But in the USSR the level already obtained in agriculture is regarded only as the initial step in the progress of all its branches towards an abundance of production. And it cannot be otherwise, because a characteristic feature of socialism is the *constant growth of the people's requirements*. And the aim of socialist production, which is developing on the basis of higher techniques, is to secure the maximum satisfaction of these constantly growing requirements.

The Nineteenth Congress of the Communist Party of the Soviet Union defined in its resolutions the ways of the country's development in the current five-year period, and stipulated that by 1955 the gross grain crop is to rise by 40-50 per cent. This means that the Communist Party is leading the Soviet people to a stage where not two but three ears of corn will grow in place of one! The tillers of the socialist fields, armed with the achievements of Soviet science and advanced practice, are quite equal to this task.

Thus far, mentioning some of the endeavours of Soviet scientists, we have not touched upon the question of the material base behind them. The achievements of Soviet science might sometimes seem miraculous and surprising to people who have been taught to see Soviet life in a deliberately distorted light. The

real scope of cultural progress in the Soviet Union is frequently underestimated. Let us therefore use the example of agricultural science for a few comparisons characteristic not only of this branch of knowledge. Comparisons of this kind may be made in any field of scientific research.

In 1917, there was not a single agricultural research institute and there were only 44 experiment stations in the country. Thanks to the daily concern of the Communist Party and the Soviet Government for advancing agricultural science, the number of agricultural research institutions founded during the 35 years of Soviet government was 13 times greater than in 40 pre-revolutionary years. The Soviet Union has 141 institutes with branches, and 474 plant-breeding and experiment stations. It is not, of course, only a question of organisational scope. Soviet science owes its successes primarily to the fact that it develops on the basis of the advanced Marxist-Leninist methods, that it is concerned entirely with the interests of the people, serving the aims of peaceful constructive labour, that it is organically and inseparably connected with practice, with production. Therefore, the discovery of the agronomist, soil scientist, or biologist finds application at once on millions of hectares of the collective-farm and state-farm fields, and the work of a collective farm experimenter becomes the subject of careful study in the research institutes. Just as an invention or improvement proposed by a rank-and-file innovator in production becomes the subject of study at the chair of technology, power engineering or mechanics and is adopted in production, the discovery of a scientist in technology, power or mechanical engineering becomes available to thousands of industrial enterprises.

Returning to the selected example, to agricultural science, we may illustrate this by concrete facts. The basis of Soviet agricultural science is Michurin agrobio-

logy, with the essence of which we shall deal later. As for its connection with life, the cooperation between science and the growing army of foremost practical agriculturists may serve as a model example. The development of a powerful industrial collective farm and state farm production opened unlimited possibilities for the advancement of talent from the midst of the people. Large groups of distinguished experts of socialist agriculture have appeared in the village. They have not only achieved major successes in production, but contributed towards the progress of agricultural science. This process of initiation of the workers of the collective farm village into science is gaining intensity year after year. Six distinguished collective farmers received Stalin Prize awards in 1945 for radical improvements in methods of production; ten representatives of the collective farm villages were honoured with these awards in 1946, and 85—in 1951-1952. The names of the Siberian field husband Terenti Maltsev, of the distinguished machine operator Ivan Shatsky, the expert in boosting corn yields Mark Ozerny, the outstanding livestock specialist Stanislav Shteiman, the famous pig tender Alexandra Lyuskova and many other foremost workers in agriculture are known in and outside the Soviet Union.

Many of these innovators in agricultural production have become members of scientific councils in the research institutes and their reports are heard at meetings of these councils along with the papers of eminent scientists. Their experience is being systematised and generalised; their books are published in the millions, and their practice is thus transferred into the realm of theory, into the realm of science, occupying a conspicuous place in scientific papers and textbooks. The farms where these foremost agriculturists work are actually transformed from places for inculcating one or another achievement of science (which

is true of any collective farm in the Soviet Union) into a base of direct scientific research. The appearance of these local centres of science is possible only in a country where science and life are bound with indissoluble ties. It should be noted that this new form of agricultural research has already taken organisational shape. In 1950, for example, the Shadrinsk State Experiment Station was founded by decision of the Soviet Government at the "Zavety Lenina" Collective Farm, in a village of the Kurgan Region. A researcher from the midst of the people, Terenti Maltsev, the collective-farm field husband, was appointed director of this station. Although only two odd years have passed since the foundation of the Shadrinsk Station, the authorities of agricultural science in the USSR believe that in this brief space of time its new, fundamentally different method of scientific research has fully justified itself.

The main subject of scientific research at this station is the development of a new system of soil cultivation proposed by T. Maltsev. This system is designated to secure in the areas beyond the Urals a continuous rise in soil fertility and a further increase in crop yields. One of the chief elements of this system is deep ploughing. The proposals of the experimenters are tested not on small plots, but on large collective farm tracts, in ordinary production conditions. In 1952, this area was visited by the severest drought in the last 30 years. But whereas thirty years ago the peasants in this district did not even recover the seeds planted, the "Zavety Lenina" Collective Farm harvested from the entire area exceeding two thousand hectares a crop of spring wheat not less than 76 poods per hectare, and the yield on a 400-hectare area was as high as 100 poods.

Maltsev, of course, is not conducting his experiments in isolation. They are part of a large programme

of scientific research designated in particular to facilitate the progress of agriculture in the vast non-black-earth zone of the European part of the Soviet Union which has large tracts of cropland, meadows and forests. This zone has a favourable climate, but the crop yields there are still low owing to the poor fertility of the soil and inadequate cultivation. To raise the crop yields in this zone it will be necessary to employ a set of measures to cultivate and deepen the arable layer, and practise more widely the liming and manuring of acid soils. Proper lea crop rotations and measures for regulating the water supply are being introduced here. Soviet soil scientists are making a detailed study of the properties of various sod-podzol and podzol soils. They are compiling large-scale soil maps indicating the characteristic features of the soils. These maps are used in working out long-range plans for raising the soil fertility on every collective farm and state farm. The present stage in the development of soil science is characterised by the reconstruction of the theory of the soil formation process and the development of soil fertility on the basis of biological principles. Soviet soil scientists are making a deep study of the role of biological factors in soil formation and the development of soil fertility in different geographical conditions.

As already mentioned above, the large detachments of research workers in the special research institutes and a still greater army of collective farm experimenters have adopted the Michurin biology, as the foundation of their work. Its principles are best of all illustrated by concrete examples of individual endeavours which represent both the result of its development and the basis of great achievements in agricultural production.

The great Soviet scientist Ivan Michurin, whose name the progressive trend in biology now bears, and

his followers summarised numerous observations of the development of plants and animals in natural conditions and a great amount of data from scientific experiments and agricultural practice. The conclusion deduced therefrom was that the action of the conditions of life on organic forms and the connection of the latter with the environment are not an accidental phenomenon but the universal obligatory means of existence and development of living organisms. Reflecting this objective law of nature, Michurin biology holds that an organism and the living conditions it requires form an inseparable unity. Moreover, environmental conditions are the determining factor in this unity. As we have already seen, it was on the basis of this very principle that the Soviet scientists traced the origin of life on Earth and proved that the transformation of non-living into living substance continues uninterruptedly in our time in accordance with the laws of nature.

But if the living springs from the non-living, it demands for its development the very elements and environmental conditions which contributed towards the development of the given organic form. The assimilation of one and the same substance from the environment and the prolonged action of definite conditions combine to mould the specific features of one or another organism and of organic forms in general. These features determine the nature of plants and animals which thus depends upon the nature of the concrete conditions of life. And the totality of specific properties of an organism which depend upon the assimilation of concrete living conditions constitutes what the Michurinists call heredity. It follows that Michurin biology defines heredity as the effect of the concentrated action of environmental conditions assimilated by the organism in a series of preceding generations.

The formation of a living body in a definite environment accounts for the fact that a plant requires those very and no other conditions. In the process of individual development these requirements of the plant change in a definite succession. This succession was disclosed and explained by Trofim Lysenko, eminent representative of the Michurin science in the USSR, in his theory of phasic development of plants. Each stage in the individual development of a plant is, as T. Lysenko has demonstrated, connected with its special requirements of conditions of life. The main requirement at the stage of germination, let us say, is a definite temperature of the environment. The photo-stage is characterised by special requirements of the plant for sunlight, for a definite intensity and duration of sunlight, etc. The requirement of a given organism for the very environmental conditions which served as the basis of its formation determines the relative stability of the nature of the organism, the conservative aspect of heredity, so to say. Organisms assimilate from the environment only substances native to their type of metabolism. But if these conditions are changed, the plant or animal of a given type faces the necessity of using other possibilities for sustaining its vital functions. Assimilating the changed conditions, organic forms undergo an alteration corresponding to the action of the environment. This may lead to an alteration in the type of metabolism, and, consequently, to a change in the entire organism as a result of the inheritance of newly-acquired properties and characters.

From this brief outline of some of the principles of Michurin biology it follows that heredity, apart from its conservative aspects (the tendency towards perpetuation of the breed), is also subject to variation. Thanks to this, it is possible to obtain desired alterations in heredity. As the latest works of T. Lysenko and his colleagues have shown, a radical change in

heredity leads to the transformation of one species into another.

This theory, which is fundamentally at variance with the dead dogma of immutable "hereditary substance" upheld by the geneticists of the Morganist school, has led to important practical results. In full conformity with their theory, the Michurinists have proved that by changing the conditions of life and altering an organism as the necessity for it arises, it is possible to direct the development of a plant or animal, to obtain directed changes in organic forms for practical purposes.

Let us mention a few examples of this great work which places the laws governing the development of organic nature at the service of the national economy.

Wild-growing plants were invariably used by the great transformer of nature Ivan Michurin in his experiments. They furnished the material from which this great scientist moulded like a sculptor and created new varieties of plants and new, enduring and productive fruit and small fruit varieties, pushing their cultivation thousands of miles to the North. The valuable properties of wild-growing plants are used through hybridisation, i.e. through crossing, directed training of hybrids and selection of the best. All these methods were employed, in particular, by the eminent Soviet biologist, Academician Nikolai Tsitsin, in order to combine in one plant the valuable properties of the "savage" of the vegetable kingdom, the harmful couchgrass weed, and of the tender wheat.

The problem of creating a wheat-couchgrass hybrid which Tsitsin solved is not so simple as it may appear at first glance. It is not in pure form that the Michurinist plant breeder transmits to the cultivated plants one or another property or a set of properties of the wild plant. By correctly training the hybrid, he

promotes and consolidates these properties to the required degree. This painstaking work conducted by Academician Tsitsin for many years was crowned with brilliant success. Planted on a production scale by the collective farms and state farms, his wheat-couchgrass hybrids proved to be highly productive (yielding 5-6 tons per hectare), and to possess great resistance to lodging and disease. The area planted in the USSR to winter wheat-couchgrass hybrids was expanded to 60,000 hectares in 1952, and is being constantly widened.

The work of the Michurinists in plant breeding is known far better than their accomplishments in the development of new breeds of animals and the alteration of the breed through training. The dogmata of formal genetics maintain that an organism's hereditary basis is independent of the conditions of its development and that it is impossible to produce valuable breeds through crossing owing to the allegedly inevitable and constant "segregation" of the progeny of hybrid animals. Disproving these dogmata, Michurinist livestock breeders have enriched agriculture with new breeds of pigs, sheep, dairy cattle and horses. The new breeds are superior to the best pedigree stock in the world, possessing greater productivity and adaptability to local conditions.

Widely known in the USSR is the scientific work of Academician Mikhail Ivanov and his pupils. It deals with the development of a new breed of pigs and sheep. Academician Ivanov set out from the premise that the new breed must and should be developed only for definite natural conditions which directly exert a decisive influence on the entire make-up and type of the animal of the future breed. He laid much emphasis on the significance of the nature of the feed and nutrition for all the internal and external features of the animal. These factors, he taught, determine the formation of new characters to a greater degree than

the breed of the animal itself, than its pedigree. Instead of the prevalent concept of breed as a "mixture of genes" which lends itself to various combinations, Academician Ivanov based his work on a thorough study of the structure of the animal and its health. In accordance with the requirements of Michurin genetics, selection and the choice of parental pairs were conducted in conditions of good nutrition, maintenance and care, because the absence of these conditions could lead to the degeneration of any breed. Academician Ivanov succeeded in developing a highly productive breed of pigs distinguished by a sturdy constitution, strong and powerful skeleton, well proportioned build, high fecundity, rapid growth and adaptability to local conditions. The productivity of this breed is well on a par with the white Yorkshire pig (the live weight of an adult pig of the new breed averaging 353 kg., its record weight having reached 405 kg.), but it has a sturdier constitution.

Still greater popularity among livestock farmers is enjoyed by Ivanov's Askania Merino, a new breed of fine-wool sheep (named after the well-known preserve of Askania-Nova, now a scientific research institute for the acclimitization and hybridization of animals). An Askania ram yields in one year enough wool for the production of superior cloth for 8 suits. Ivanov's pupils and followers conducted extensive creative work on the breeding of another fine-wool sheep, the Caucasian breed. A new breed of fine-wool sheep developed in Kazakhstan possesses a very strong constitution and its adaptability to range pasturing is on a level with that of the local, coarse-wool, fat-rumped sheep.

However, the greatest achievement of Michurin biology in dairy farming is the new Kostroma breed created by a group of workers of the "Karavayevo" pedigree stock farm (Kostroma Region) directed by

Stanislav Shteiman, a Stalin Prize winner. His profound knowledge of the physiology of highly productive livestock has prompted the Michurinist S. Shteiman to organise the entire life and nutrition regimen of the animal so as to accomplish the basic task: to intensify the metabolism of the cow to a very high degree and make it the normal rate of the animal's existence. That is why animals cannot be selected or chosen for mating on the basis of one or on the basis of separate indices of productivity, but the whole complexity of the animal's properties must be taken into account.

Proceeding from creative Darwinism and Michurin's theory, Shteiman formulates his theoretical concepts as follows: "The purpose of pedigree stock breeding is not to sustain the hereditary characters of the animal on the level already attained, but to promote their constant development and the constant perfection of the herd. Each successive generation must be superior to its predecessor." The results achieved on the basis of these principles may be illustrated by the following facts: scores of cows on this farm yield more than 10,000 kg. of milk a year, and the famous milcher of the Karavayevo herd, "Poslushnitsa Vtoraya," produced a record yield of 16,262 kg. of milk in 368 days of its sixth lactation period. The attention paid to the proper build and general health of the animal has a favourable effect on the duration of the lactation period. The herd of this state farm includes scores of good milchers past 12 years of age. The lifetime milk yield of some of these has already surpassed 100,000 kg. The "Skhema," for example, has yielded as much as 4.8 tons of butter alone in its adult life.

It is, however, not only a question of raising the milk yield of cows. The main achievement to the credit of the Karavayevo farm workers is the

development within a short space of time of an entirely new breed which is superior in the totality of its properties to the best breeds in the world developed over scores of years.

The principle of remaking the nature of farm animals through training is being thoroughly elaborated in Soviet science. Of interest in this respect are Shumsky's experiments with horses, the experiments on monkeys in Slonim's laboratory, and the investigations of Professor Pshenichny conducted on sheep, pigs, rabbits and birds. All these investigators proved, for example, that given the same level of nutrition, various frequencies of feeding lead to deep changes in the animal's metabolism. Frequent feeding (6-8 times a day) intensifies carbohydrate metabolism, whereas rare feedings (1-4 times daily) intensify fat metabolism, tend to fatten the animal, to facilitate a more sparing expenditure of the reserves of the organism. A rhythmic change in the conditions of life is one of the most powerful means in the hands of men for remaking an animal's nature.

While emphasising some of the practical achievements of Michurin science, I do not wish to convey to the reader the impression that the research conducted by the scientific institutions in this sphere is limited entirely to the solution of narrow practical tasks. The fruitful effects of Marxist-Leninist methodology and the natural organic ties of science with life make Soviet science highly effective. But precisely because great significance is attached in the USSR to methods of scientific research, Soviet scientists are advancing theoretical investigations in every field of knowledge. This thesis, mentioned at the very beginning of the review, may be illustrated by examples from the branches of science dealt with here. Mention may be made of an extensive series of investigations concerned with the problem of vegetative hybridization, i.e. uniting in

one organism the properties of two organisms, without sexual reproduction. The work on this problem gives the investigator a more profound grasp of the essence of heredity and of the ways of its directed alteration.

I. V. Michurin's experiments and generalisations relating to the problem of vegetative hybridization of plants are widely known. His pupils and followers base their idea of vegetative hybridization as treated by Michurin biology on the premise that any particle of the living body possesses the property of heredity, and that in vegetative hybridization the plastic substances of one partner penetrate the body of the other, producing a corresponding change in its heredity. Michurin himself was extensively employing vegetative hybridization for the purpose of breeding superior fruit and small-fruit varieties. He proceeded from the premise that seedlings of perennial fruit plants obtained through sexual hybridization possess in the majority of cases one or another set of undesirable characteristics. For example, a highly cold-resistant and fertile hybrid may frequently bear fruit of mediocre taste. In other cases the fruit are superior, but the tree itself possesses low resistance to cold and low yield. It may happen that the hybrid tree regularly yields a high crop and its fruit are good in every respect save one: when picked from the tree they spoil rapidly and cannot be stored for a long time. All these shortcomings are eliminated by grafting cuttings of a plant possessing the valuable properties the hybrid lacks on to the crown of the latter. These cuttings, or "mentors," as Michurin called them, transmit to the stock their hereditary properties and qualities. The nature of a plant may also be remade by grafting cuttings of a hybrid seedling on to the crown of a tree possessing valuable properties.

On the basis of this principle, the workers of the Central Genetics Laboratory in Michurinsk are success-

fully remaking the nature of plants, training in their hybrids properties valuable for the national economy. The well-known plant-breeder Chernenko, a pupil of Michurin, has succeeded in improving the remarkable new varieties of apples he created (the "Nezhnaya" and "Suvorovets"). Chernenko raised the frost-resistance of these plants, while preserving all their valuable properties. He accomplished this by grafting cuttings of these apple trees on to the crown of central-Russian frost-resistant varieties. The two varieties acquired such high resistance to cold that they may now be cultivated in the orchards of the collective farms and state farms in the central zone. The "mentor" method was employed also in remaking the nature of another of Chernenko's apple trees, "Pamyat Shevchenko." This variety was freed from a serious shortcoming; the premature fall of the fruit.

These examples could be mentioned in the hundreds.

It is of interest that the method of vegetative hybridization has been tested by Soviet experimenters also on animals. In this case, vegetative hybridization cannot, of course, be understood merely as the union of two organisms. It includes all the phenomena of assimilation, of the mutual influence of organisms. The methods employed in vegetative hybridization of animals include transplanting of ovaries, of fertilized and unfertilized egg cells, the replacement of the white in bird eggs, blood transfusion and the coalescence of organisms. From the extensive series of experiments in this field we shall mention the experiment of Bogolyubsky who revealed the full possibility of combining alien albumins in the process of incubation. The method employed in this experiment was as follows: the experimenter removed a definite amount of the white from a fertilized egg and then injected an equal amount of alien albumin (no more than 20 per cent as

a rule). The new conditions influence the development of the embryo; it assimilates these conditions and its nature changes correspondingly.

Of interest also are Sopikov's experiments in vegetative hybridization of animals through blood transfusion. This spectacular experiment was carried out on the white leghorn and the "Australor" hens which have a black plumage. The result was a generation of hens with a white plumage in the main, but some had black feathers or with a black plumage in the main with some hens having white feathers. The hybrids had a better capacity for growth and a greater live weight. From his experiments Sopikov deduced that the living cells of the donor's blood had been assimilated and contributed towards the formation of the germ cell of the recipient, and thus changed the heredity of the organism.

Science is only taking its initial steps in the vegetative hybridization of animals, but even these first experiments are highly important. They indicate that the vegetative hybridization of animals is quite possible and confirm the thesis of Michurin genetics that all particles of a living body are endowed with heredity.

Selfless Service to the Cause of Peace and Democracy

EMPHASISING THE NOVEL features in the researches of Soviet scientists, we did not by any means wish to belittle the significance of the progressive scientific legacy of the past. Nevertheless, Soviet scientists hold that to preserve the heritage of the past does not at all imply to confine themselves to this heritage. They are creatively developing science, plumbing the essence of phenomena, without fear to concretise or even to reject one or another thesis if it fails to con-

form to the latest data of science. This creative approach to the scientific legacy is in the spirit of progressive science which illumines the road for practice.

The development of Soviet science shows that whereas science inevitably withers, degenerates and is reduced to an agglomeration of obsolete dogmata when it is severed from life and fails to take into account the requirements of society, to detect the new and progressive, it yields the most fruitful results when it is deeply rooted in life, in practice, when it has chosen the course of bold innovations, when it takes into account and generalises the experience of innovators in production.

The powerful progress of Soviet science takes place under the Soviet socialist system on the basis of the most advanced theory, Marxism-Leninism. The significance of the encouragement given to scientific research by the Communist Party and the Soviet Government is evident in the development of the Academy of Sciences of the USSR (the institutes functioning under its auspices have carried out most of the investigations mentioned in this review). A small, secluded institution before the Revolution, the Academy is now the world's biggest association of research institutes and laboratories. All the peoples of the multi-national Soviet state are making their contribution towards the progress of Soviet science. Fruitful work is done, along with the Academy of Sciences of the USSR, by the Academies of Sciences founded in the Ukrainian, Byelorussian, Georgian, Azerbaijan, Armenian, Uzbek, Kazakh, Tajik, Turkmen, Latvian, Lithuanian and Estonian Soviet Socialist Republics.

"Selfless service to the cause of peace and democracy," wrote the President of the Academy of Sciences of the USSR, Alexander Nesmeyanov and the Chief

Scientific Secretary of the Academy, Alexander Topchiyev, recently, "is a great inspiration to Soviet science. Science is powerful. In it are concentrated the treasures of the human genius of many generations. But science is only a means. Everything depends upon the classes controlling it and the purposes for which it is used: for construction or for destruction. In the USSR and the People's Democracies science works in the service of the cause of peace, for the security of the people, for improving the well-being of the working people. Soviet scientists urge the scientists of all countries to prevent the use of scientific inventions and discoveries in the interest of a handful of imperialists for destroying human life and cultural treasures created through the labour of generations. By their peaceful labour, Soviet people are building the material and technical foundation of Communist society in our country. Soviet scientists are and will be employing all their energy and knowledge for the purpose of strengthening the might of the Soviet Motherland."

